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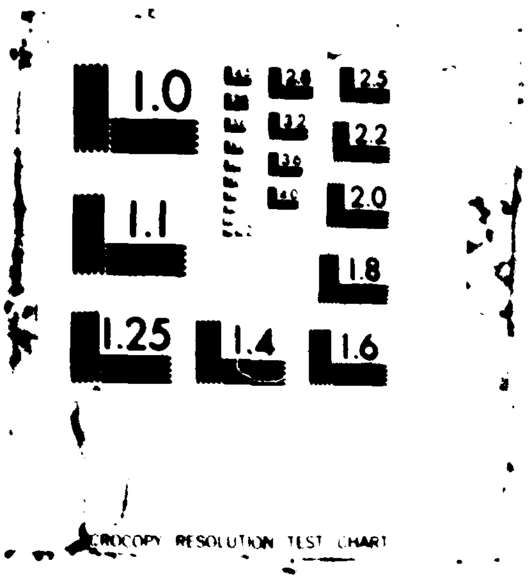
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CROCOPY RESOLUTION TEST CHART

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PULMONARY ADAPTATION TO HIGH ALTITUDE

ANNUAL PROGRESS REPORT
14 November 1984 - 1 February 1986

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Our studies demonstrated the causes and consequences of periodic breathing during sleep at high altitudes, showed the susceptibility of the highly trained athlete to development of hypoxemia during heavy exercise at even very moderately high altitudes, and tested the effect of exercise in hypoxia on respiratory muscle fatigue.

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We have completed work concerned with 3 major problems related to performance of the pulmonary system during exercise and sleep in hypoxia.

1. Sleep in Hypoxia

We completed our study of the relationship between hypoxia-induced periodic breathing in sleep and the occurrence of obstructive apnea. We used normal subjects and those who might be "susceptible" to upper airway closure, i.e., heavy snorers and even some patients with obstructive sleep apnea syndrome. As expected we found that administration of hypoxia caused immediate hypocapnia leading to a Cheyne-Stokes type of oscillatory breathing pattern which caused marked increases in airway resistance during the periods of low ventilatory drive. The surprising finding was that once full-blown periodic breathing developed--after about 5 minutes of hypoxia--airway resistance was markedly reduced to levels $\leq$ than those observed while awake and no evidence of occlusive apnea occurred. The conclusion is that hypoxia must have exerted a protective effect on the upper airway, by ensuring that as inspiratory drive increased toward the end of each apneic period, activity to the muscles controlling upper airway caliber was greater than and/or preceded that to the diaphragm and other inspiratory muscles of the chest wall. Further studies are now needed of the EMG activity of these upper airway and chest wall muscles to determine their relative activities during the apneic periods. This "protective" mechanism is central to the sojourner at high altitude--particularly the heavy snorer--to guard against occlusive apnea and even greater nocturnal hypoxemia.

2. <u>Individual Susceptibility to Exercise-Induced Hypoxemia in a Hypoxic Environment</u>

We studied fit, healthy subjects during very heavy exercise and determined the relative contribution of various factors which would cause marked hypoxemia when <u>very mild</u> levels of hypoxia were imposed (.17 to .18 inspired % O_2) on 4 to 6 runs of exercise at 85 to 95% of max VO_2. Two factors clearly dominated the cause of marked hypoxemia under these conditions:

1) The absoulte <u>exercise oxygen consumption</u>. The fitter the subject, the higher the VO_2--thus the lower the mixed venous O_2 content and the greater the probability for incomplete gas exchange. Arterial PO_2 was fairly well maintained in normal subjects at resting levels (PaO_2 75-80 mmHg)--whereas, in the highly fit PaO_2 fell 20 to 30 mmHg during exercise.

2) <u>The magnitude of the ventilatory response</u>. The subject whose ventilation responded vigorously to the combination of exercise plus hypoxia tended to defend his resting PaO_2 better than the subject--even the highly fit subject--who did <u>not</u> ventilate vigorously. Of course the physiologic cost of this extra ventilation may present yet another problem to the performance of the endurance athlete at high altitude. (See Aim 3.)

3. <u>Endurance Exercise Performance</u>

The question of <u>respiratory muscle fatigue during exercise</u> in humans was studied in highly fit subjects performing high intensity exercise to exhaustion. First we found that a partial "unloading" of ventilatory work--by breathing low density $He:O_2$ gas mixtures--significantly increased exercise endurance time to exhaustion and reduced "perception" of effort. On the other

hand our additional data did not implicate the mechanical work of breathing during exhaustive exercise as an important contribution to overall fatigue. We determined the pleural pressure wave form and magnitude generated each breath during exhaustive exercise. Then we mimicked this form and magnitude of pressure development at rest and found that the subject could tolerate this form of pressure development for much longer times than he could exercise. Work continues on this project in normoxic and hypoxic conditions with the added aim of determining the oxygen cost of breathing.

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